Dyscalculia Test

Technical Manual

Developed by Smartick

Contents

1. Dyscalculia 3
1.1. What is it? 3
1.2. Dyscalculia or difficulty learning mathematics? 4
1.3. Dyscalculia at School and in Daily Life 4
1.3.1. *At School* 4
1.3.2. *In Daily Life* 5
1.4. Comorbidity 6
2. Dyscalculia Test 7
2.1. Objectives 7
2.2. Skills Evaluated 7
2.3. How to Take the Test 9
2.3.1. *Who, When, and Where* 9
2.3.2. *Age* 10
2.3.3. *Administration Time* 10
2.4. Results and Report 10
2.5. Diagnosis of Dyscalculia 11
3. Test Statistics 12
3.1. Validation Study 12
3.2. Participants 12
3.3. Reliability 14
3.4. Validity 14
3.4.1. *Convergent Validity* 14
3.4.2. *Content Validity* 15
3.4.3. *Study with a Sample of Children with Math Learning Difficulties* 16
4. References 17

Dyscalculia

1.1. What is it?

Dyscalculia is a specific learning disorder of neurobiological origin that affects the acquisition of knowledge about numbers and calculation despite an IQ within the normal range. It has an estimated prevalence of 5 to 7%, which is similar to that of dyslexia (Butterworth, Varma and Laurillard, 2011; Geary, 2011).

Dyscalculia is a very heterogeneous disorder, but generally, children with dyscalculia experience difficulties with the most basic aspects of numerical processing and calculation. Additionally, math learning difficulties manifest differently depending on age. The ideal age for detecting a risk for dyscalculia is between ages 6 and 8. However, the first symptoms can appear in children as young as preschool age.

Some basic numerical skills, such as the ability to differentiate between quantities, counting, or digit recognition are considered specific precursors of mathematical learning. Children with dyscalculia have problems in these areas of numerical processing and as a result, lack the basis for developing more advanced mathematical knowledge (Landerl, 2013).

When considering the performance of children with dyscalculia on these basic math tasks, it is important to note that not only do they make more mistakes, but they are also slower than their peers when completing these tasks (Mussolin, Mejías and Noël, 2010; Landerl, Bevan and Butterworth, 2004).

1.2. Dyscalculia or difficulty learning mathematics?

Having trouble with mathematics does not always mean having dyscalculia. Other causes may explain issues with math, such as low intellectual level, inadequate educational methods, or reduced exposure to numerical experiences. In the case of children with special education needs, difficulties with math could be the consequence of a specific condition other than dyscalculia.

1.3. Dyscalculia in School and in Daily Life

1.3.1. At School

At school, math difficulties for children with dyscalculia can translate to poor performance in math class, while their performance in the rest of their school subjects remains unchanged. These math learning difficulties manifest differently depending on age:

Indicators of Dyscalculia in Preschool:

- Problems learning to count. For example, children cannot remember numbers in the correct order or when they are asked for four units of something, they are only able to take a handful instead of counting it out.
- Difficulty understanding terms related to mathematics, such as ‘bigger’ and ‘smaller.’
- They cannot understand the relationship between number and quantity. For example, they do not understand that ‘4’ applies to groups of ‘4 cakes,’ ‘4 cars,’ or ‘4 friends.’

Indicators of Dyscalculia in Primary School:

- Difficulties identifying +, -, and other mathematical symbols, and how to use them correctly
- Difficulty learning and remembering numerical facts (for example: 2+8, 4x7)
- Continued use of fingers to count in place of other, more advanced, strategies – such as mental calculation
- Difficulty understanding words related to mathematics, such as ‘greater than’ and ‘less than’
- Problems with visual-spatial representations of numbers, such as number lines
- Difficulty understanding the place value of numbers (ones, tens, hundreds)
- Problems writing numbers or putting them in the correct column in written calculations

1.3.2. In Daily Life

Difficulties in learning math that are typical in children with dyscalculia do not just affect school. Dyscalculia can create difficulties in children’s daily lives because math is everywhere. We need mathematical skills to tell time, calculate how long it will take us to get home, know how much our groceries will be, or understand how to cut a cake into equal slices.

Additionally, the impact of mathematical skills on people’s academic future and future employment is even greater than that of reading difficulties (Parsons & Bynner, 2005). This is why identifying dyscalculia in children as soon as possible is crucial, as early intervention can help reduce the problem.

1.4. Comorbidity

Scientific literature indicates that out of all children with dyscalculia, only half show difficulties exclusively within the numerical field (Kaufmann and Von Aster, M., 2012; Von Aster and Shalev, 2007). This data means that they can have dyscalculia exclusively, but it also implies that between 20 and 60% of children with dyscalculia present symptoms of learning challenges associated with it.

The problems with which dyscalculia occurs more often are ADD and dyslexia. However, dyscalculia can also occur with learning disorders such as language and motor developmental disorders, or even emotional problems (such as anxiety).

Dyscalculia Test

2.1. Objectives

The goal of this test is to quickly and easily detect math learning difficulties in children who may be at risk for dyscalculia.

2.2. Skills Evaluated

According to the literature on dyscalculia and the development of mathematical skills, this test includes tasks for evaluating three key areas of mathematical learning:

- **Comparison and recognition of quantities:** Pre-symbolic numerical cognition includes at least two cognitive abilities: automatic and immediate recognition of small sets of elements (subitizing), and the ability to perceive and differentiate large numbers (supported by the Approximate Number System). These pre-symbolic skills begin to develop in children from the first months of life.

  However, children with dyscalculia have problems with the representation and handling of quantities (Piazza et al 2010; Schleifer y Landerl, 2011; Ashkenazi, Mark-Zigdon & Henik, 2013), and, in turn, these problems predict difficulties in tasks involving the manipulation of symbolic numbers. This test has included two representative exercises: one for quantity comparison and another for subitizing.

- **Dot Comparison:** Differentiating between two quantities without counting - in other words testing the efficiency of the Approximate Number System (ANS)

- **Subitizing:** Recognizing small sets of numbers at a glance, without counting

- **Arabic numbers and numbering:** Six numerical processing exercises using the verbal symbolic code are included in this area. In particular, children's knowledge of numbers is assessed through a task of number recognition (individuals listen to a spoken number and are asked to identify the corresponding digit) and a number comparison task (individuals are asked to select the number with the highest value from two numbers). Two more tests evaluate the internal representation of numbers on a mental number line, the formation of which is a vital step in the development of mathematical skills (Von Aster y Shalev, 2007).

  The final two tests in this area evaluate counting with an exercise for counting elements, and a numerical sequence exercise. Shortcomings in dyscalculia include the immature or improper use of counting strategies and a lack of flexibility when using a numerical sequence.

  - **Number Recognition:** Assigning a verbal label to a set of numbers

- **Number Comparison:** Identifying the largest of two numbers
- **Mental number line:** Estimating the distance between numbers on a number line
- **Number line:** Positioning numbers 1 – 100 on a number line without markers
- **Counting:** Counting sets of elements
- **Numerical Sequences:** Finding the rule needed to complete a series of ordered numbers

- **Arithmetic:** Children with dyscalculia are characterized by their severe and persistent inability to learn arithmetic (Butterworth et al., 2011). Three arithmetic exercises have been included in the dyscalculia risk test that require children to perform simple addition, subtraction, and multiplication operations. The multiplication task is not included in the test when evaluating first graders.

Student performance on these tests is considered in terms of accuracy and speed of execution.

2.3. How to Take the Test

2.3.1. Who, When, and Where

The dyscalculia risk test can be used by schools, professionals, and families.

No prior experience is required to administer the test. However, it is important for the test to be taken in a quiet place and for the student to complete it on their own, without any help, in order to not invalidate the process.

A tablet is needed in order to complete the dyscalculia risk test.

2.3.2. Age

This test it suitable for students from 1st to 4th Grade. For older students, the starting point will be 4th Grade.

2.3.3. Administration time

The test is administered individually online, and lasts approximately 15 minutes. This is only a guideline; the total test time will depend on the student's profile.

2.4. Results and Report

The dyscalculia risk test quickly and easily identifies children with math learning difficulties that are at risk for dyscalculia, and reports their strengths and weaknesses in each of the evaluated areas.

The student's results will be presented in percentiles, scores that indicate the percentage of individuals who have a score equal to or less than that of the student. Percentiles determine an individual's place in relation to the standardization sample.

For example, if a student is in the 80th percentile for the *numerical sequence* task, it means that if we compare the score to 100 students in the same grade, there will be 80 individuals with a lower score and 20 with a higher score on the task. As a guideline, percentile scores equal to or less than 10 are considered indicative of serious difficulties on a given task. The Dyscalculia Test has been standardized among the Spanish population. Use of the test with children from other countries may affect the results.

The results will be sent to the contact information provided. If the evaluation shows a profile that is at risk for dyscalculia, we recommend contacting a professional for a full evaluation.

2.5. Dyscalculia Diagnosis

If a student is deemed at risk according to their results on the dyscalculia test, parents and teachers should see a school psychologist who has knowledge of dyscalculia or be referred to a school counselor for a full evaluation. The evaluation should include psychological tests for intelligence, attention, and reading, along with specific math tests.

After the diagnosis it is recommended to inform the student that he or she has a specific learning issue. Afterward, a **specific and comprehensive intervention** should take place, which includes specific work with a learning disorders intervention specialist, family involvement, and special accommodations made in school. Smartick activities can help considerably during this process.

Test Statistics

3.1. Validation Study

The dyscalculia test has been developed by Smartick in collaboration with the University of Malaga and the University of Valladolid. In total, more than 800 students from different areas of Spain participated in various stages of the validation study for this test. During the first part of the research, the feasibility of the first proposal was tested with a pilot study. After this first stage, the final items were selected, and the final test was designed and developed. The last stage consisted of the collection of definitive samples for the standardization processes.

3.2. Participants

737 children, from 1st to 4th grade participated in the standardization of the dyscalculia test (see Table 1). The children come from public, private, and charter schools in the regions of Castile and León, Madrid, and Andalusia. Children with Special Education Needs (SEN) such as ADD, ADHD, limitations in intellectual functioning, aural difficulties,, and dyscalculia were excluded from the final sample.

Grade	Number of participants
1°	180 (84 M; 96 F)
2°	188 (90 M; 98 F)
3°	184 (95 M; 89 F)
4°	184 (80 M; 104 F)

Table 1. Distribution of the participant sample by grade

In Table 2, you can see the **descriptive data** for each of the tasks included in the test, distributed by age group. Since we have dichotomous variables, the mean of accuracy is the percentage of children who responded correctly to the item. Reaction times are presented in seconds. As expected, the percentages of correct responses on all tasks increase with children's age and performance. In terms of reaction times, they are better in older children compared to their younger peers.

Specifically, the children's performance in the 11 tasks included in the test significantly correlate with their chronological age (all p <.001).

	Accuracy				Time			
	1°	2°	3°	4°	1°	2°	3°	4°
DOT COMPARISON	79%	85%	89%	90%	189	160	145	135
SUBITIZING	94%	98%	98%	99%	173	149	134	123
NUMBER RECOGNITION	90%	98%	98%	99%	285	278	256	243
NUMBER COMPARISON	88%	96%	96%	97%	220	188	162	141
MENTAL NUMBER LINE	74%	89%	90%	97%	354	339	310	248
NUMBER LINE	87%	93%	94%	95%	662	649	587	510
COUNTING	87%	92%	94%	94%	556	489	455	406
NUMERICAL SEQUENCES	64%	81%	84%	90%	504	410	368	324
ADDITION	76%	90%	95%	97%	527	439	355	278
SUBTRACTION	70%	88%	91%	94%	528	407	353	280
MULTIPLICATION		75%	85%	90%		509	443	337

Table 2. Descriptive information by grade

3.3. Reliability

The reliability analysis is intended to see the internal consistency of the designed instrument. Cronbach's alpha (1951) was used, which tells us the extent to which the test items are related. Table 3 shows **the total reliability** of the test in each of the grades taking into account the variables of accuracy and time.

GRADE	ACCURACY	TIME
1º GRADE	.935	.880
2º GRADE	.873	.908
3º GRADE	.840	.933
4º GRADE	.661	.926

Table 3. Cronbach's alpha reliability

3.4. Validity

3.4.1. Convergent Validity

Convergent validity refers to the degree to which the test correlates with other tests that measure the same construct. The Basic Instrumental Aspects Test has been used to explore the convergent validity of this test (PAIB; Ramos, Galve, Martínez and Trallero, 2009).

PAIB: Basic Instrumental Aspects Test in language and mathematics. It is a test developed in Spain to complete the evaluation of aspects related to language and mathematics and the assessment of performance, curricular skills, and maturity in these areas.

For the calculation of correlations with the external criterion, the direct scores obtained in the numbering and calculation PAIB subtests were taken into account.

We correlated these values with two scores from the dyscalculia risk test (numbering and calculation), created by adding the total scores in the numbering tests (Number Recognition, Number Comparison, Mental Number Line, Counting, Numerical Sequences) and calculation tests (Addition, Subtraction, Multiplication) included in the overall test.

The correlation coefficients between the scores from the dyscalculia risk test and the PAIB subtests in different grades are reported in Table 4. All correlations are significant.

	Numbering	Calculation
1º GRADE (N=39)	.64**	.76**
2º GRADE (N=45)	.61**	.56**
3º GRADE (N=44)	.35*	.49**
4º GRADE (N=43)	.66**	.36*

Table 4. Correlation coefficients between PAIB and the dyscalculia risk test

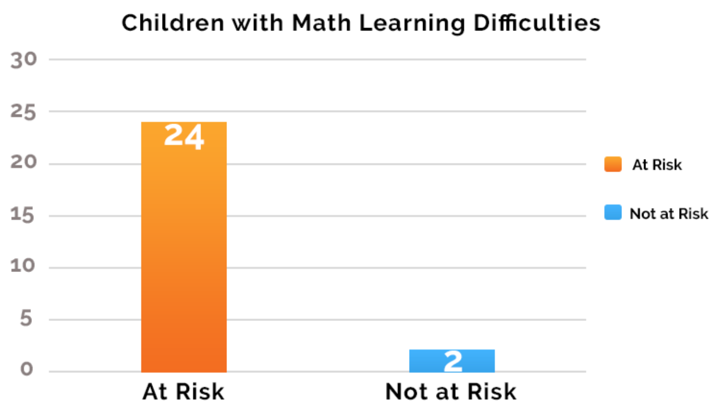
3.4.2. Content Validity

Recent literature on dyscalculia and the evaluation of mathematical learning was taken as a reference in the preparation of each of the tasks that make up the dyscalculia risk test. The main scientific references have been presented in the "skills evaluated" section of this technical manual.

In the final version of the dyscalculia risk test, those aspects of mathematical learning that should be mastered (in terms of accuracy and response times) by most children who do not have dyscalculia were considered.

3.4.3. Study with a Sample of Children with Math Learning Difficulties

To explore the effectiveness of the dyscalculia risk test in identifying 'at risk' children, a group of children with severe math learning difficulties (N=26) took the test, with help from school counsellors.



The results show that this test has identified 92% of children as at risk for dyscalculia.

References

Ashkenazi, S., Mark - Zigdon, N., & Henik, A. (2013). Do subitizing deficits in developmentaldyscalculiainvolvepattern recognition weakness?. Developmental Science, 16(1), 35-46.

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: from brain to education. science, 332(6033),1049-1053.

Parsons, S. & Bynner, J. (2005). Does Numeracy Matter More? London: National Research and Development Centre for adult literacy and numeracy, Institute of Education, University of London.

Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. Journal of developmental and behavioral pediatrics: JDBP, 32(3), 250.

Kaufmann, L., & von Aster, M. (2012). The diagnosis and management of dyscalculia. Deutsches Ärzteblatt International, 109(45), 767.

Landerl, K. (2013). Development of numerical processing in children with typical and dyscalculic arithmetic skills—a longitudinal study. Frontiers in psychology, 4, 459.

Landerl, K., Bevan, A., & Butterworth, B. (2004). Developmental dyscalculia and basic numerical capacities: A study of 8–9-year-old students. Cognition, 93(2), 99-125.

Mussolin, C., Mejias, S., & Noël, M. P. (2010). Symbolic and nonsymbolic number comparison in children with and without dyscalculia. Cognition, 115(1), 10-25.

Piazza, M., Facoetti, A., Trussardi, A. N., Berteletti, I., Conte, S., Lucangeli, D., ... & Zorzi, M. (2010). Developmental trajectory of number acuity reveals a severe impairment in developmental dyscalculia. Cognition, 116(1), 33-41.

Ramos, J. L., Galve, J. L., Martínez, R., & Trallero, M. (2009). PAIB: Prueba de aspectos instrumentales básicos en lenguaje y matemáticas. Madrid: CEPE

Schleifer, P., & Landerl, K. (2011). Subitizing and counting in typical and atypical development. Developmental science, 14(2), 280-291.

Von Aster, M. G., & Shalev, R. S. (2007). Number development and developmental dyscalculia. Developmental Medicine & Child Neurology, 49(11), 868-873.